U.S. Department of Transportation
**Federal Aviation Administration**

# Memorandum

Subje **INFORMATION**: Policy for 14 CFR § 33.87, Endurance test.

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From Manager, Engine and Propeller Directorate, Aircraft Certification Service

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## 1. PURPOSE.

a. This policy memorandum provides additional guidance to establish a uniform approach for Aircraft Certification Offices (ACOs) to evaluate and approve up to a 2-minute gas temperature overshoot limit caused by thermal mismatch of engine hardware.

b. This policy memorandum supersedes FAA policy memorandum number 2000-33.87-R2, "Policy for Determining Compliance to 14 Code of Federal Regulations (CFR) § 33.87," issued April 21, 2000.

c. This policy memorandum applies to all classes of turbine engines governed by part 33.

## 2. RELATED DOCUMENTS.

a. Advisory circular (AC) 20-24B, Qualification of Fuels, Lubricants and Additives for Aircraft Engines, issued December 20, 1985.

b. AC 33-2B, Aircraft Engine Type Certification Handbook, issued June 30, 1993.

b. Part 33—Airworthiness Standards; Aircraft Engines

## 3. BACKGROUND.

a. The FAA has been asked to consider a 2-minute gas temperature overshoot limit approval within the 5-minute steady state gas temperature limit associated with the takeoff power or thrust rating established under § 33.7, for certain engine operating conditions. This 2-minute approval addresses a condition in which a gas temperature overshoot occurs due to a decrease in engine cycle efficiency caused by a difference in the thermal growth rate of the engine cases and rotors. This condition is most pronounced when an engine is accelerated to takeoff from a cold state.

(1) For turbine engines installed on rotorcraft, this temperature overshoot excursion condition could be significant because rotorcraft flight operations typically accelerate the engine from a cold state.

(2) For turbine engines installed on fixed-wing aircraft, such overshoot excursions would not be expected to occur regularly during takeoff operation, due to the time spent from engine start, through push back and taxi, to takeoff. However, the following are examples of flight conditions where this gas temperature overshoot limit could be used:

- engine acceleration during first takeoff of the day;
- engine acceleration from a cold soak windmilling condition;
- engine acceleration from low Mach number during hot day conditions, such as certain corner points of the flight envelope or aircraft go-around operation.

b. The FAA will consider proposals for a gas temperature overshoot limits greater than 30 seconds and less than or equal to 2 minutes, within the 5-minute maximum steady state gas temperature limit proposed for the takeoff power or thrust rating.

(1) This overshoot limit is intended to address the gas temperature excursion during certain engine acceleration conditions in which a thermal differential of hardware growth between engine outer cases and rotors occurs. Since the overshoot is part of the 5-minute steady state temperature limit, an engine should be removed from an aircraft for maintenance whenever the engine fails to produce rated takeoff thrust or power for both the overshoot and the 5-minute steady state temperature limits.

c. In reviewing § 33.87(a)(3), the FAA has determined that the phrase, "must be 100 percent of the value associated with the particular engine operation being tested," may be applied to cover the proposed gas temperature overshoot. Therefore, the FAA has revised this policy to provide guidance for demonstrating a gas temperature overshoot limit up to 2 minutes, in compliance with § 33.87(a)(3), within the 5-minute time limit associated with the takeoff power or thrust rating. Paragraph 5.f. of this policy provides a means for demonstrating compliance through test for this additional gas temperature overshoot limit and identifies regulations whose means of compliance would be affected by this policy.

**4. HISTORY.**

a. Recently, several engine manufacturers have proposed the incorporation of more service representative type tests in place of the endurance cycle defined for engines in § 33.87. However, the intent of § 33.87 is not to simulate in-service operation, but to require an accelerated severity test to demonstrate a level of engine operability and durability within the engine ratings and limitations.

b. Since the origination of endurance testing, the test cycles and operating limits requirements have remained virtually unchanged. Yet a review of recent and past data shows that the FAA has accepted various alternative approaches to the very specific requirements of this rule, some of which deviate too much from the rule to continue to be acceptable. For example, running the "more than one test" allowance of § 33.87(a)(3) on multiple hardware sets instead of a compiled demonstration on one set of engine hardware is unacceptable.

c. On October 1, 1974, the FAA published Amendment 6 to part 33, which revised § 33.87(a) and added subparagraphs (1) through (9) to update the requirements for turbine engines. For § 33.87(a)(8), the need to develop requirements to evaluate transient overshoots was based on the type of engine control used on turbine engines at that time. Those controls were primarily proportional hydromechanical control systems, which exhibited transient overshoot characteristics due to limitations in the methods for gain compensation. Today's controls have technology that includes proportional plus integral systems, permitting a high gain and compensation in the control loop and minimizing transient overshoot characteristics.

d. The intent of § 33.87(a)(8) is to define a method for certifying rotor speed and gas temperature transient overshoots associated with proportional hydromechanical control systems

while conducting the endurance test required by § 33.87. However, § 33.87(a)(8) has been used inappropriately to substantiate limits for gas temperature when temperature limits were exceeded up to as much as 120 seconds. There have also been cases in which transient limits greater than 30 seconds have been used as supplementary limitations for engine power-setting purposes. Specifically, § 33.87(a)(8) is intended to evaluate rotor speed and gas temperature transient overshoots for periods of 30 seconds or less. Paragraph 5.e. of this policy restates the intent of § 33.87(a)(8) and identifies how rotor speed and gas temperature limits, other than transient overshoots, may be certified.

e. In summary, the endurance test for compliance with § 33.87 constitutes an inseparable part of an engine durability certification process that has provided an acceptable level of safety for more than 40 years. As the industry became more complex and specialized, the need for upgrading part 33 airworthiness standards in test and design requirements became evident, including § 33.87. In responding to these needs, the FAA announced an Aircraft Engine Regulatory Review Program in 1977, solicited rule change proposals from the aviation and general communities, and conducted a review conference. This conference permitted the public to provide evidence of outdated regulations and appropriate measures to deal with new technology and was attended by industry and public representatives. On February 23, 1984, the FAA published Amendment 10 to part 33 based on information received during the review program and conference. That significant amendment incorporated regulations to clarify and update test and design requirements including lessons learned from certification and service experience from turbofan engines. Section 33.87 was updated at that time and included revisions to several of the paragraphs in § 33.87(a). Since amendment 10 § 33.87 has been changed a number of times in response to new technology and new usages such as engine ratings, however minimal and minor change has been made to the paragraphs of § 33.87(a). Thus, for §§ 33.87(a)(3), (a)(7), and (a)(8), these regulations are determined adequate to address the issues discussed in this memorandum.

**5. POLICY STATEMENT.** The following methods provide an acceptable means of compliance with § 33.87 for the situations specified:

a. New Type Certificate. Run the standard 150-hour endurance test as prescribed in § 33.87 with no deviations.

b. Amended Type Certificate. Run the standard 150-hour endurance test as prescribed in § 33.87 with no deviations, unless the following applies:

(1) Derivative model with no or minor design changes and the same or lower ratings or operating limitations. The original 150-hour demonstration still applies.

(2) Derivative model with design changes and the same or lower ratings or operating limitations. These changes, if viewed individually or in combination, would have no impact on engine operability or durability within the approved ratings and limitations; data from the original test would fully substantiate the proposed changes.

(3) Derivative model with major design changes and the same or lower ratings or operating limitations, for which the ACO has determined that a repeat demonstration of the test prescribed in § 33.87 is needed to substantiate the design change. Run the standard 150-hour endurance test cycle as prescribed in § 33.87(b) through (f), as applicable, with no deviations. Compliance with all subparagraphs of § 33.87(a) is required. The ACO will determine which subparagraphs of § 33.87(a) are affected by the proposed changes and require reevaluation by test and which subparagraphs are covered by existing data from an applicable § 33.87 test, from which compliance findings by similarity can be made.

(4) For all other cases, a standard 150-hour endurance test as prescribed in § 33.87, with no deviations, is required. The above exceptions are based on the assumption that a 150-hour endurance test has been conducted on the original model or subsequent derivative model, in accordance with the requirements of § 33.87, such that data from that previous test would apply. If this is not the case, then the ACO should contact the Engine and Propeller Standards Staff to determine an acceptable approach for compliance.

c. Major Design Change. If the ACO determines that a major design change will require a repeat demonstration of § 33.87, then the standard 150-hour endurance test cycle as prescribed in § 33.87(b) through (f), as applicable, with no deviations, must be run. Compliance with all subparagraphs of § 33.87(a) is required. The ACO will determine which subparagraphs of § 33.87(a) are affected by the proposed changes and require reevaluation by test and which subparagraphs are covered by existing data from an applicable § 33.87 test, from which compliance findings by similarity can be made.

d. Engine Operating Limitations.

(1) Section 33.87(a)(3) allows multiple tests if all limits associated with the engine operating condition (that is, takeoff, maximum continuous, one engine inoperative (OEI), etc.) being demonstrated cannot be held simultaneously. If multiple tests are necessary, the additional test(s) must be run in accordance with the prescribed test sequences of § 33.87(b), (c), (d), (e), or (g), applicable to the operating condition being demonstrated, and must be run on the same engine hardware presented for certification. For example, for engines other than certain rotorcraft engines (§ 33.87(b)), testing the takeoff rating may require a second test to demonstrate the fan speed limit, if core rotor speed limit and gas temperature limit have been demonstrated simultaneously during the first test. The second test would run at fan rotor speed limit and gas temperature limit, simultaneously, in accordance with the test sequences defined in § 33.87(b)(1), (b)(2)(ii), and (b)(5). This second demonstration would accumulate an additional 42.5 hours of testing, resulting in a total time of 192.5 hours on the same engine hardware for this endurance test.

(2) For rotorcraft engines for which 30-second OEI and 2-minute OEI ratings are desired, the applicant must repeat the test sequence defined in § 33.87(f) for a total time of not fewer than 120 minutes. If a second test is required to demonstrate all the limits associated with the engine operating condition, then the total test time at the desired OEI conditions must not be fewer than 240 minutes.

(3) Section 33.87(a)(3) also states that at least 100% of the value of all the parameters associated with a particular engine operating condition must be obtained during the series of runs specified in § 33.87(b) through (g), as applicable. If a parameter (such as speed) for a particular engine rating (such as maximum continuous) is not defined, then the applicant should test the maximum engine "redline" condition.

(4) The limits included in the engine type certificate data sheet as required by § 33.7 must be less than or equal to those demonstrated during the endurance test for each engine operating condition evaluated.

e. Transients.

(1) Section 33.87(a)(8) states that the transient conditions must be demonstrated during the acceleration cycles required by § 33.87(b) through (f), as applicable. The following are the acceleration cycles of (b) through (f):

- (b)(1) and (b)(5);
- (c)(1), (c)(2) and (c)(5);
- (d)(1), (d)(3) and (d)(6);
- (e)(1) and (e)(2); and
- (f)(1), (f)(2) and (f)(6).

Advisory circular (AC) 33-2B describes a transient as a rotor speed or gas temperature value that exceeds the approved limit for a period of 30 seconds or less for transients associated with the takeoff, continuous OEI, and 30-minute OEI ratings. Transients associated with the 2.5-minute, 2-minute, and 30-second OEI ratings should be limited to very brief periods, on the order of 5 to 10 seconds maximum. These transient limits for rotor speed and gas temperature may not be used as supplementary limitations, regardless of their duration, for engine power setting purposes.

(2) After a detailed review of the requirements of § 33.87(a)(8), the Engine and Propeller Directorate has concluded that § 33.87(a)(8) is intended, and remains a suitable method, to evaluate rotor speed and gas temperature transient overshoots for periods of 30 seconds or less.

f. Gas Temperature Overshoot Limit.

(1) To demonstrate a gas temperature overshoot limit greater than 30 seconds and less than or equal to 2 minutes, in compliance with § 33.87(a)(3), the applicant must demonstrate the proposed gas temperature overshoot limit value and duration for each period at takeoff power or thrust conditions, and for the entire time of all the 30-second periods at takeoff power or thrust unless § 33.87(a)(7) applies.

(2) For example, an applicant proposes a 2-minute gas temperature overshoot limit as part of the 5-minute maximum permissible limit proposed for rated takeoff. The applicant would be required to demonstrate 6 hours and 35 minutes of the 18.75 hours required by § 33.87(b)(1),

(b)(2)(ii), and (b)(5), at the 2-minute overshoot temperature limit. The type certificate data sheet would then specify:

(a) A 2-minute overshoot out of a 5-minute maximum permissible gas temperature limit for the takeoff rating as follows

- Takeoff (5-minute)
- Takeoff (2-minute overshoot out of a total of 5 minutes); and

(b) A note that indicates that the engine must produce rated takeoff thrust or power within both the 2-minute overshoot and the 5-minute steady state redline temperature limits.

(c) When the engine cannot meet the two requirements stated in paragraph (b) above, it must be removed from service for maintenance.

(3) The proposal of a 2-minute gas temperature overshoot limit would require the demonstration of test requirements of §§ 33.27(c)(1) and 33.88 using the 2-minute gas temperature value as the maximum steady state operating temperature limit.

(4) For approval of a gas temperature overshoot limit that exceeds 2 minutes, the applicant must demonstrate the overshoot temperature value for the entire 18.75 hours, as defined in § 33.87(b)(1), (b)(2)(ii) and (b)(5).

**6. EFFECT OF POLICY.**

a. The general policy stated in this document does not constitute a new regulation or create a "binding norm." Whenever an applicant's proposed method of compliance differs from this policy, it must be coordinated with the Engine & Propeller Directorate Standards Office, ANE-110, through the issue paper process or equivalent. In addition, if an office believes that an applicant's proposal that meets this policy should not be approved, that office must coordinate its response with the Engine & Propeller Directorate Standards Office, ANE-110.

b. Applicants should expect that the certificating officials will consider this policy when making findings of compliance relevant to new and amended certificate actions. This policy statement identifies one issue that will be considered when determining whether an applicant has shown compliance with § 33.87, and offers one means, but not the only means, of showing compliance with the rule for that issue. The FAA, in appropriate circumstances, reserves the right to require that an applicant take additional actions in order to show compliance with the rule on this issue.

## 7. CONCLUSION AND RECOMMENDATIONS.

a. This policy:

(1) does not preclude the endurance testing of the accessory gearbox or any accessory drive or mounting attachment on a separate rig as allowed in § 33.87(a)(6);

(2) does not prohibit the allowance of a 500-hour controlled flight test, as defined in AC 20-24B, as an acceptable alternative to the requirements of § 33.87(a)(4) for fuels and lubricants; and

(3) does not prevent the pursuit of an exemption in accordance with part 11.

b. Testing that the FAA has previously approved in support of § 33.87 that falls outside the acceptable approaches provided in this policy has resulted in confusion and the ultimate rejection of that testing by the Joint Aviation Authorities (JAA) in support of Joint Aviation Requirements-Engines (JAR-E) 740. Presently, the requirements of § 33.87 and JAR-E 740 are generally accepted as equivalent. Therefore, the Engine and Propeller Directorate strongly recommends that the applicant be informed that previous testing that falls outside the approaches in this policy should be coordinated with the JAA early in the program if JAA validation is desired. The JAA may determine that additional testing is required to comply with JAR-E 740.

c. The Engine and Propeller Directorate recommends the implementation of this policy upon receipt. Any applicant proposals outside the scope of this policy should be coordinated with the Engine and Propeller Standards Staff.

*Original signed by RG on 8/24/04*
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